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3D documentation of outcrop by laser scanner — Filtration of vegetation☆

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Summary This work deals with separation of vegetation from 3D data acquired by Terrestrial Laser Scanning for detecting more complex geological structures. Separation of vegetation is not an easy task. In many cases, the outcrop is not clear and the vegetation outgrows the outcrop. Therefore the separation of vegetation from 3D data is a task which requires adjustment of algorithms from image processing and remote sensing. By using cluster analysis and analysis of spectral behaviour we can detect vegetation from the rest of the scene and erase these points from the scene for detection of geological structures.

Introduction

LASER scanning systems (terrestrial or aerial) together with digital photogrammetry or SAR interferometry belong nowadays to commonly used techniques of land surface description. The number of their applications increases alongside with the price affordability of these devices. In the field of geosciences, in connection with Terrestrial Laser Scanning (TLS) or Lidar (Light Detection And Ranging), 3D computer visualisation outcrops have started to be created, commonly referred to as a DOM — Digital Outcrop Model (Bellian et al., 2005; Gigli and Casagli, 2011) or as a VO — Virtual Outcrop (McCaffrey et al., 2005). Lidar is an established method for rapidly obtaining three-dimensional geometry of outcrop, with unparalleled point density and precision (Buckley et al., 2013).

In the year 2000, Bryant et al. (2000) published their work focused on the production of DOM for the purposes of petroleum industry where the advantages of 3D computer visualisation outcrops were demonstrated. With the increasing popularity of GPS, total station, digital photographs and Lidar, other works dedicated to this topic emerged (McCaffrey et al., 2005; Hodgetts, 2013). For example, Slob et al. (2005) used Lidar in civil and mining engineering works dealing with rock masses which require a good understanding of discontinuities (joints, faults, bedding) in the rock

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mass. Consequently, many authors tried to extract structural elements from a thoroughly created 3D outcrop through semi-automatic or automatic detection.

Gigli and Casagli (2011) attempted to create semi-automatic extraction of ten parameters for the quantitative description of discontinuities in rock masses (orientation, spacing, persistence, roughness, wall strength, aperture, filling, seepage, number of sets, and block size) for the purposes of engineering geology. For an automatic identification of discontinuities at a granite quarry, Deliormanli et al. (2014) used Lidar as well as optical methods. Buckley et al. (2013) tried to use hyperspectral imaging not only for identification of structural elements, but also for mineral composition. Hartzell et al. (2014) made a similar effort by using radiometrically calibrated TLS for a complex description of outcrops. These efforts led to the development of specific tools or software: i.e. Vulcan; Surpac; 3DM analyst; 3DGeomec (Gigli and Casagli, 2011).

Lidar — advantages and disadvantages

Nowadays, the application of Lidar is becoming still more and more popular in geological sciences. It is a powerful device offering a lot of advantages for the collection of terrain data. Nonetheless, we agree with Hodgetts (2013) that Lidar will not replace traditional fieldwork and fieldtrips.

According to a number of authors (Gigli and Casagli, 2011; Slob et al., 2005; Hotgetts et al., 2004), the advantages of Lidar are: the possibility to collect data from otherwise inaccessible areas; minimum safety risk; virtual viewpoints — being able to view the data from many different angles; the possibility to analyse outcrops in the office; increased sample size — as it obtains data from every part of the outcrop; generation of new attributes — it records attributes which can be otherwise overlooked in the terrain; rapid data collection — 10's to 100's thousands of points per second; improved use of fieldwork time; it enables more objective description of the outcrop.

Among the disadvantages, we find the following: unhandiness of the device due to its heavy weight; poor battery life and its long charging time. When scanning, vegetation is a sort of a handicap, as it covers the view of the outcrop. Another disadvantage can be seen in a large number of data which may be difficult to process and interrogate (Hotgetts et al., 2004).

Aim of the work

The above-stated procedures are demonstrated by the authors merely on the outcrops with simple structural terraces. In most of the works, DOM of sedimentary rocks with sub horizontal folds or monoclines were created. None of the authors (Bellian et al., 2005; Gigli and Casagli, 2011; McCaffrey et al., 2005; Buckley et al., 2013; Bryant et al., 2000; Hodgetts, 2013; Slob et al., 2005; Deliormanli et al., 2014; Hartzell et al., 2014; Hotgetts et al., 2004) has carried out an extraction and detection of the structural elements on the outcrops of folded sedimentary rocks. None of them has either published a work demonstrated on the outcrops of tectonically affected metamorphic rocks. Therefore our second goal is to develop a semi-automatic detection system of the structural terraces working also in the difficult geological conditions. Before we can proceed to the detection itself, we need to solve the problem of separation of vegetation from the data cloud. Our article deals with this problem.

Methodology

3D scans were obtained using a Stonex X300. It is a compact 3D scanner with a pair of cameras for capturing RGB scene and a 2.5—300 m range laser beam. Stonex X300 enables to scan in the horizontal range of 360° and vertical range of 90°. Its big advantage is high precision of 6—40 mm and high scanning speed of 40,000 points a second.

The basic principle of scanning outcrops is choosing the number of viewpoints and their position. We try to place the viewpoints in such a way so there will not emerge blind spots in the final data cloud caused by the shades from vegetation or from the profile outcrop. Then the targets are placed, serving for mutual connection of point clouds from the viewpoints.

The processing of points into a single data cloud was carried out in the program Stonex Reconstructor which enables the connection of the individual viewpoints into one viewpoint based on the targets, and exporting them to various formats. In this work, we used export to format x3d which is from the xml language family and which enables easy processing in Python language. To compile software for vegetation processing, we used OpenCV and scikit in Python language.

Separation of vegetation

The separation of vegetation is one of the first problematic tasks when working with a Terrestrial Laser Scanner. The vegetation often overlaps the scanned area and causes problems with the automatic processing of the point cloud. The correct removal of vegetation creates the basis for subsequent data processing. Many authors (Bellian et al., 2005; Gigli and Casagli, 2011; McCaffrey et al., 2005; Buckley et al., 2013; Bryant et al., 2000; Hodgetts, 2013; Slob et al., 2005; Deliormanli et al., 2014; Hartzell et al., 2014; Hotgetts et al., 2004) describing vegetation removal from 3D data indicate examples in which the vegetation, mainly trees, do not overlap the scanned area. Those are often individual trees located in front of the quarry wall or outcrop. In such cases, the separation of vegetation is based on the distance from the quarry wall and the manual removal is quite easy because the points representing the vegetation are simply cut out or erased from the point cloud. With automated vegetation removal in such easy cases, assessing the distance of points from the furthest points in the direction of measurement is used.

In our work, where we are trying to create a procedure and software for general use, it is necessary to think about the separation of vegetation in the most difficult locations against the geological outcrop. The vegetation often overgrows the outcrop (Fig. 1) or the trees and bushes grow directly on the rock. Thus, separation of vegetation by using distance based filters which were applied in the simple